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ABSTRACT

The Continuity Project is a research, development, and technology transfer initiative aimed at creating a Library of the Future by combining features of an online public access catalog (OPAC) and a campuswide information system (CWIS) with advanced facilities drawn from such areas as artificial intelligence (AI), knowledge representation (KR), natural language processing (NLP), computer applications and software engineering (CASE), literate programming, hypertext research, and computer supported cooperative work (CSCW). By taking this approach, Continuity will be able to provide an intelligent, unified, and proactive information infrastructure for the learning organization of the future. The explosive growth rate of the body of accumulated knowledge and increasingly powerful information technology and computing tools have exceeded the capabilities of traditional approaches to cataloging and collection management. In the new millennium, the ability to find and integrate relevant existing knowledge is the new limiting factor on the rate of scientific and commercial innovation. This report contains the following sections: "The Continuity Project"; "Continuity at a Glance" -- graphics that embody the most salient features of the Project; "The Continuity Experience" -- an informal treatment of what it would be like to use Continuity in an academic setting; "Project Participants; and Sources of Inspiration." (DLS)

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ED 422 025

The Continuity Project
Spring/Summer 1998 Report

By:

Peter J. Wasilko

IR057150

U.S. DEPARTMENT OF EDUCATION
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Peter J. Wasilko

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Continuity

An Extensible Intelligent Integrated Collaborative Catalog & Distributed Institutional Memory Archive

The Continuity Project

Welcome to The Continuity Project!

The Continuity Project is a new research, development, and technology transfer initiative aimed at creating a Library of the Future by combining features of an on-line public access catalog (OPAC) and a campus wide information system (CWIS) with advanced facilities drawn from such areas as artificial intelligence (AI), knowledge representation (KR), natural language processing (NLP), computer applications and software engineering (CASE), literate programming, hypertext research, and computer supported cooperative work (CSCW). By taking this approach, Continuity will be able to provide an intelligent, unified, proactive, information infrastructure for the learning organization of the future.

Such systems were first envisioned as far back as the 1930's when the first hints of information overload were beginning to appear on the horizon. Since then, the body of accumulated knowledge held in our collections has grown at a truly explosive rate with disciplines spawning sub-disciplines far to rapidly for even the finest research libraries to keep pace. Moreover, this growth of total knowledge is locked in an accelerating feedback loop with the development of increasingly powerful information technology and computing tools. Our traditional approaches to cataloging and collection management were never designed to cope with these dynamics.

Thus as the new millennium approaches, the ability to **find and integrate relevant existing knowledge,** rather than the need to make discoveries *de novo,* is emerging as a new limiting factor on the rate of scientific and commercial innovation. Indeed, even the most basic of original pure research is often predicated on just such an understanding of its antecedents.

Since this ability to innovate and facilitate innovation is, and will no doubt remain, the primary source of competitive advantage at the firm, regional, and national level, the importance of creating such advanced active information infrastructures can not be stressed too highly.Indeed, the creation of tools to augment our cognitive abilities goes to the very heart of the Technopolis Strategy ■ of promoting advanced technology for economic development.

■ See *The Technopolis Phenomenon : Smart Cities, Fast Systems, Global Networks* Edited by David V. Gibson, George Kozmetsky, and Raymond W. Smilor. (Rowman & Littlefield Publishers, Inc., 1992)

■ *The Wagon Wheel* bar in Mountain View has been credited as the key catalyst for many of Silicon Valley's semiconductor industry collaborations. See *Regional Advantage : Culture and Competition in Silicon Valley and Route 128* by Annalee Saxenian. (Harvard, 1994)

Thus Continuity would serve as a virtual Wagon Wheel ■ bringing together people, ideas, and resources to establish a much more intimate continuity between authors and readers, between researchers and practitioners, between librarians and patrons, between students past and present, and between the university and its community.

Today, it is just too much work to find new people, ideas, projects, and resources using our current tools. The catalog lacks the depth of coverage, the campus web lacks the organization and automated access, and our would be collaborators (be they on campus or in the community) lack the time to sift through it all.

With your help, Continuity will change all that.

> *It is time to reconceptualize the role of the library and refashion the online catalog into an intelligent proactive medium for the social construction of knowledge.*

Research Directions

The time is ripe to move forward. In March of 1997, Daniel E. Atkins of *The University of Michigan's School of Information & the Department of Electrical Engineering and Computer Science* organized a *National Science Foundation Planning Workshop on Distributed Knowledge Work Environments : Digital Libraries* in Santa Fe, New Mexico. The purpose of the workshop was to evaluate the results to date as the initial period of funding for digital library research under the NSF / DARPA / NASA Digital Library Initiative (DLI).

The group also made a number of observations to guide those contemplating future work, which it summarized as follows, in the Abstract of its final report:

> Some desirable distinctions between the current DLI and future programs include the following. Current DLI involves broad technical agendas, experimental, technology testbeds, modest support for content & collections, narrowly circumscribed context of evaluation, and few user/usage studies. Suggestions for future initiatives should, by contrast, have refined technical agendas, real-world testbeds emphasizing interoperability and integration, increased support for content and collections, operational systems containing collections of value to domain applications, broad, multidimensional contexts of evaluation, and user/usage-oriented focus. Some participants further stressed the need for more emphasis on the applications of digital libraries. This was proposed in order to build user support for digital libraries, to deliver value to teachers and scholars in different contexts, to link up with the commercial publishing world, and to focus research in the most valuable directions.

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Desiderata

Continuity will be a New Millennium OPAC Designed to Function as a User-Centric Collaborative Knowledge-based Learning System.

The catalog needs to provide its users with grounding in fields that are new to them. It should offer both visualizations of the collection and of scholarly activity using the collection. It should support subjective queries and be able to handle a natural language dialog. Over time it should develop personal profiles of its users and tailor its responses to better meet their needs. It should help them to get into contact with one another and to update the overall store of knowledge to manage errata and incomplete leads. It should unify the OPAC and CWIS with tools for organizing and sharing personal research. ●, ●, ●

To achieve these objectives, Continuity needs to capture extensive meta-knowledge about its subject mater, and the most reasonable way to build such a store of knowledge is to gather it in small measures over time from a large number of users as transparently as possible. ■ Moreover, the system must scale up economically to support more users and domains of knowledge and it must be extensible over time so that it can integrate new technologies, new media, and new data types along with new domain specific control heuristics.

Taken together with the foregoing desiderata, these considerations lead to our ultimate design goals. Thus in its ultimate form, Continuity will provide *An Extensible Intelligent Integrated Collaborative Catalog and Distributed Institutional Memory Archive.*

Extensibility

It will have at its highest levels, an object oriented systems architecture to promote well factored system enhancements. ● It will expose an application programmer's interface and provide network access protocols to support low level third party extensions and cooperation with remote processes. It will have (and provide hooks to develop additional) interfaces to view and manipulate HTML, HDF, and other raw data formats. It will provide a mechanism to refine the ontologies used by its subsystems to better support the unique aspects of key domains like Law. It will be programmable at a high level by its end users in a multiparadigm programming / scripting language to encourage the development of new facilities to seamlessly augment the capabilities of the base system. The programming environment must support the linguistic phenomenon known as Code Switching so that users can mix programming languages and invoke metaprogramming facilities to modify the evaluation of their code. Taking Literate Programming and Subject-Oriented Programming ■ as points of departure, we call our new approach Context-Oriented Programming. ●●, ③

Intelligence

The system needs to be able to respond to natural language queries, both to support access by user with low-end hardware and to provide an alternative to the direct manipulation paradigm in controlling visualizations. ② It should have plan recognition capabilities and maintain user profiles so it can resolve ambiguities, handle ellipsis, and most importantly, base its recommendations on the needs of individual users. It should support some form of *non-monotonic authority control* so it can capture, recover from, and work with incomplete (or even erroneous) citations. It needs a heuristic basis to provide context sensitive evaluations of the credibility and utility of individual sources and authorities. It should offer a scalable adaptive user interface and provide extensive context-sensitive help to minimize training and support costs.

Integration

It must provide a uniform interface to print and digital resources. It should unify the library catalog with the campus-wide information system. It needs to support and combine both graphical and textual modes of interaction with its users. It should also incorporate models of people, organizations, concepts, and artifacts. Since the system must be extensible, it must support *computer programs* as a key class of artifacts and should therefore support their direct invocation through the system (see Licklider's *Libraries of the Future*). A *literate notetaking* environment should be provided to produce both highly readable documentation/notes and executable code/knowledge base entries as an integral part of the system's design. ● In short, the system must provide a complete information infrastructure that facilitates research, analysis, and publication. ●

Collaborative Cataloging

The system should rely on a broad spectrum of objective and subjective input from its users to refine and extend its knowledge over time. System-wide security protocols, including provision of *statistical database security* , must be implemented to guarantee *user control* of access to their personal profiles and borrowing patterns on a fine grained basis (eg. a user might elect to make public all borrowing and comments not related to some sensitive topic like "personal retirement planning"

■ See "Pattern Hatching: Subject-Oriented Design" by John Vlissides in *C++ Report* V. 10, No. 2, February 1998, p. 41-45.

■ See "Pattie Maes on Software Agents : Humanizing the Global Computer", *IEEE Internet Computing*, Vol. 1, No. 4, July/August 1997 in which Professor Maes posits that instead of taking a centralized approach to knowledge base development (e.g. The Cyc Project), one would do better to "have a system that asks anyone who's online at the moment", p. 14.

research). It should employ a *cybernetic* design with *social control heuristics* to encourage cooperative behavior, guide its future growth, and optimize the utility of its resource allocations. It should provide a mechanism to route and retain questions and recommendations for future research. It should offer a variable grain of coverage to reflect the needs and interests of its user community (ie. some areas may contain little more than current catalogs while others will have fully developed subject outlines, video ASK systems ■ to introduce and evaluate resources, and extensive ongoing critical discussions). It should directly support user-user interaction with directory services and interactive communication facilities with optional anonymity. It should be pro-active and directly initiate queries of recognized experts as one of its information seeking strategies as well as suggest possible collaboration between researchers exhibiting similar interests.

Distributed Storage & Processing

This is implicit in our need to support personal computer, work station, and personal digital assistant based satellite systems for transparent personal use in note-taking and *information farming* ■ through which the system can learn. By pre-clustering the collection into various subject matter domains and storing them on separate departmental servers ❽, ❾, it will be possible to exploit the parallelism inherent in our organization of the record to deliver faster response times and prune the search tree to offer more contextually sensitive help. A distributed architecture will also scale more readily and offer performance that gracefully degrades under increased system loads and an expanding user base. Moreover, by avoiding the need to store all of the systems knowledge in a centralized store we can significantly increase the forty odd gigabytes of storage employed by current systems without facing a cost prohibitive investment in new high-end computer hardware.

An Institutional Memory Archive

It should be structured as a heterarchy of nodes representing and preserving the intellectual activities of entire organizations, departments, workgroups, projects, and individuals. It should retain compressed archival records of all substantive transactions (ie. those containing opinions, evaluations, theories, and suggestions) at each level for subsequent use. It should even record erroneous hypotheses, incomplete citations, hunches, and possible leads, all of which can prove to be of significant value. It must offer sophisticated filtering capabilities and employ heuristic search algorithms to make this bounty accessible. Finally, it should directly model and offer visualizations of the use of the collection itself with which we may optimize resource allocations and gain substantive insights into the growth and direction of entire disciplines!

Forging the Future

The preceding analysis, which we continue to refine, embodies our goals for The Continuity Project. During the course of its development we will progressively phase in greater levels of functionality over time until the lines between our research prototypes and the evolving production system eventually dissolve.

We will follow a *Technology Fusion* ■ strategy and incorporate entire subsystems and infrastructures from external partners leaving us free to focus on technology integration and to leverage research results developed over the last fifty years to create a truly unique and powerful library of the future.

Our system design and implementation plans are consicely presented herein, both graphically ❶, ❷, ❸, ❹, ❺, ❻, and through vingettes ①, ②, ③. We offer more technical detail in ❶, ❷, ❻❻ and ③. However, this document is not intended to serve as a tutorial on Continuity technologies or as a comprehensive literature guide. If we have alluded to your work without formal citations, please understand that the decision was a fuction of our desire to target a general audience and minimize the size of this packet. If you would like literature pointers to any topics presented in these pages, or would like to know more about Continuity, please visit our web site or contact the Director.

We would be most deeply honored to work with you.

■ The reader concerned with such pedagogical issues in the context of science and innovation is commended to see *Discovering : Inventing and Solving Problems at the Frontiers of Scientific Knowledge* by Robert Scott Root-Bernstein. Harvard, 1989. If your interest goes more to the use of technology to facilitate education, see *Engines for Education* at <http://www.ils.nwu.edu/~e_for_e/> by Roger C. Schank and Chip Cleary. The Institute for the Learning Sciences, 1994. The former work is also a rich source of insight in the development of a general research ontology. The later, while ostensibly focused at the K-12 level, serves as a functioning example of an ASK system that also touches on the all to common problem of inadequately indexed "inert" knowledge at <http://www.ils.nwu.edu/~e_for_e/nodes/NODE-19-pg.html>.

The ILS Technical Report series at <http://techreport.ils.nwu.edu/> is a gold mine of ideas for case-based reasoning and computer aided instruction. Reports #2 and #25 bear particular attention.

■ See <http://www.eastgate.com/squirrel/FAQ.html#Theory>

■ See *Emerging Patterns of Innovation : Sources of Japan's Technological Edge* by Fumio Kodama. (Harvard Business School Press, 1991).

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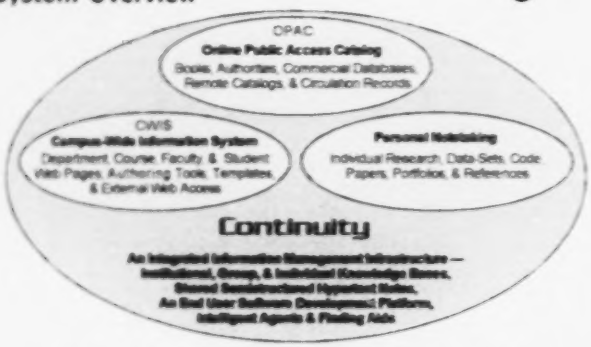
Continuity

An Extensible Intelligent Integrated Collaborative Catalog & Distributed Institutional Memory Archive

Continuity at a Glance

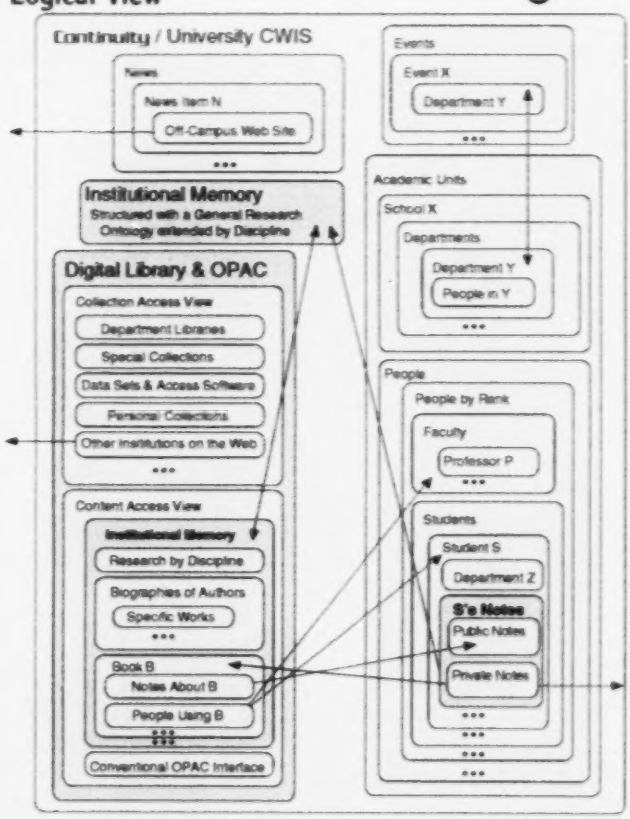
In these pages you will find a number of graphics that embody the most salient features of The Continuity Project.

System Overview ❶


OPAC
Online Public Access Catalog
Books, Authorities, Commercial Databases, Remote Catalogs, & Circulation Records
CWIS
Campus-Wide Information System
Department, Course, Faculty, & Student Web Pages, Authoring Tools, Templates, & External Web Access
Personal Notetaking
Individual Research, Data-Sets, Code, Papers, Portfolios, & References
Continuity
An Integrated Information Management Infrastructure — Institutional, Group, & Individual Knowledge Bases, Shared Semistructured Hypertext Notes, An End User Software Development Platform, Intelligent Agents & Finding Aids

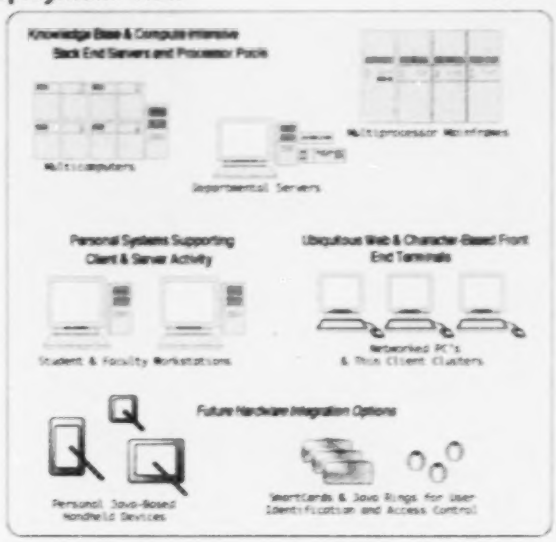
This view summarizes the major functional components and capabilities of the Continuity System.

Logical View ❷



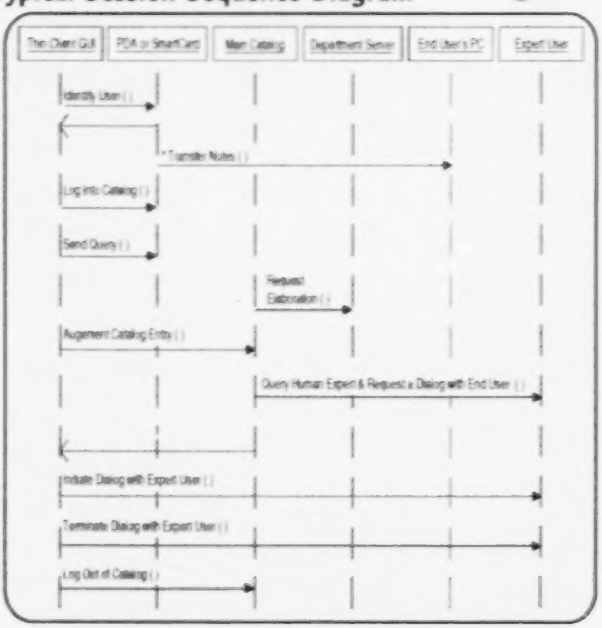
Here we present a logical view of Continuity, which is organized on the Indra's Net Model of Cyberspace ■ (INMC) to permit users to embed arbitrarily complex representations of any portion of the system at any level within the system.

Deployment View ❸


Knowledge Base & Compute-Intensive Back End Servers and Processor Pools
Multicomputers
Departmental Servers
Multiprocessor Mainframes
Personal Systems Supporting Client & Server Activity
Student & Faculty Workstations
Ubiquitous Web & Character-Based Front End Terminals
Networked PC's & Thin Client Clusters
Future Hardware Integration Options
Personal Java-Based Handheld Devices
SmartCards & Java Rings for User Identification and Access Control

This view reflects the web-based distribution of computing tasks & data across multiple hardware architectures.

Typical Session Sequence Diagram ❹


Thin Client GUI
PDA or SmartCard
Main Catalog
Department Server
End User's PC
Expert User
Identify User ( )
Transfer Notes ( )
Log into Catalog ( )
Send Query ( )
Request Elaboration ( )
Augment Catalog Entry ( )
Query Human Expert & Request a Dialog with End User ( )
Initiate Dialog with Expert User ( )
Terminate Dialog with Expert User ( )
Log Out of Catalog ( )

Here we see how computation is partitoned across a range of physically distributed systems to create the illusion of a single seamless computational environment.

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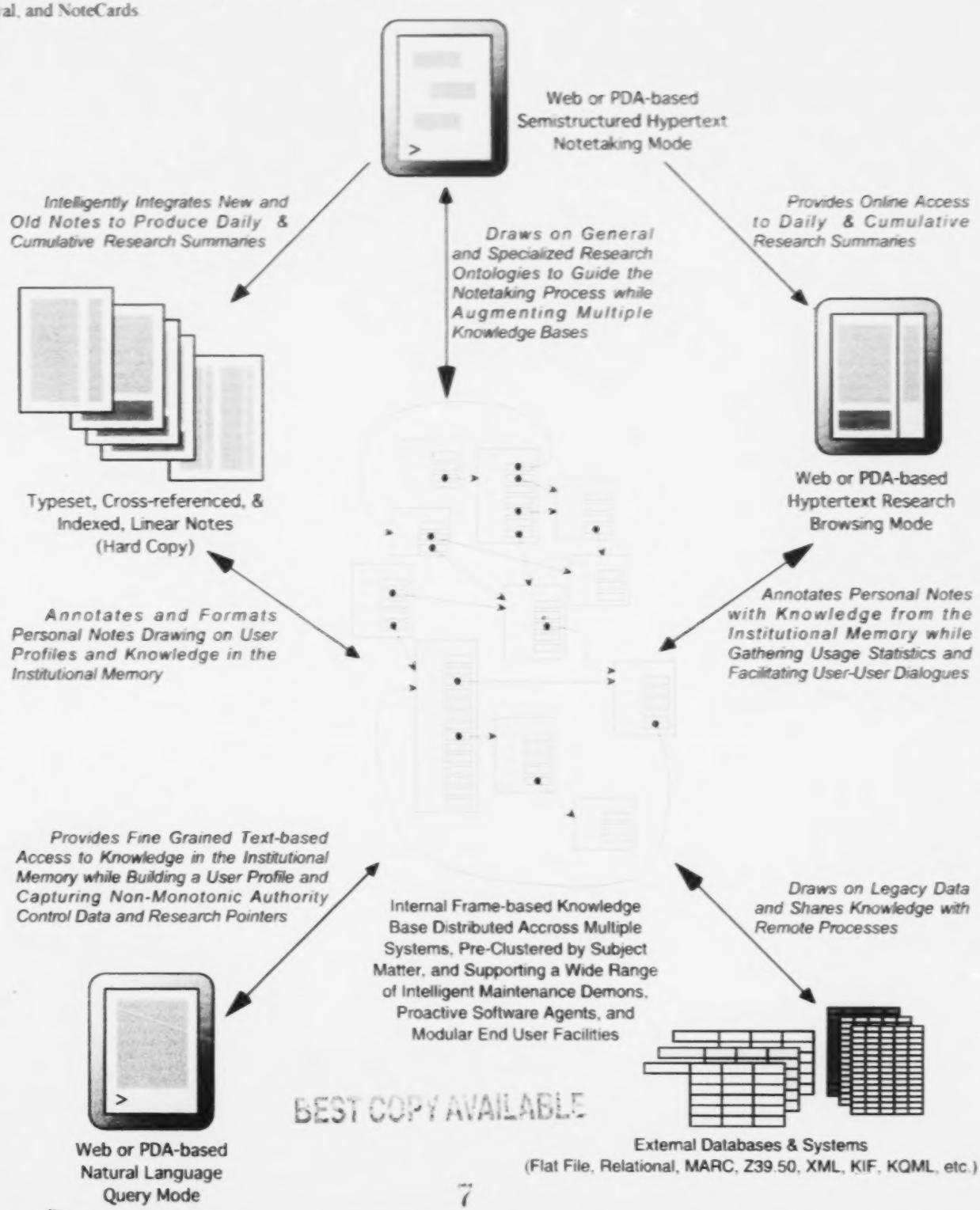
■ See "Notes on the Structure of Cyberspace and the Ballistic Actors Model" by Tim McFadden in *Cyberspace: First Steps* edited by Michael Benedikt; MIT Press, 1991.

Literate Notetaking

The Continuity Notetaking Component presented here is primarily inspired by Donald E. Knuth's classic "Literate Programing" first published in *The Computer Journal* 27 (1984), pp. 97-111 and such systems as Object Lens, gIBIS, Oval, and NoteCards.


Web or PDA-based
Semistructured Hypertext
Notetaking Mode
Intelligently Integrates New and Old Notes to Produce Daily & Cumulative Research Summaries
Draws on General and Specialized Research Ontologies to Guide the Notetaking Process while Augmenting Multiple Knowledge Bases
Provides Online Access to Daily & Cumulative Research Summaries
Typeset, Cross-referenced, & Indexed, Linear Notes (Hard Copy)
Web or PDA-based Hyptertext Research Browsing Mode
Annotates and Formats Personal Notes Drawing on User Profiles and Knowledge in the Institutional Memory
Annotates Personal Notes with Knowledge from the Institutional Memory while Gathering Usage Statistics and Facilitating User-User Dialogues
Provides Fine Grained Text-based Access to Knowledge in the Institutional Memory while Building a User Profile and Capturing Non-Monotonic Authority Control Data and Research Pointers
Internal Frame-based Knowledge Base Distributed Accross Multiple Systems, Pre-Clustered by Subject Matter, and Supporting a Wide Range of Intelligent Maintenance Demons, Proactive Software Agents, and Modular End User Facilities
Draws on Legacy Data and Shares Knowledge with Remote Processes
Web or PDA-based Natural Language Query Mode
External Databases & Systems
(Flat File, Relational, MARC, Z39.50, XML, KIF, KQML, etc.)

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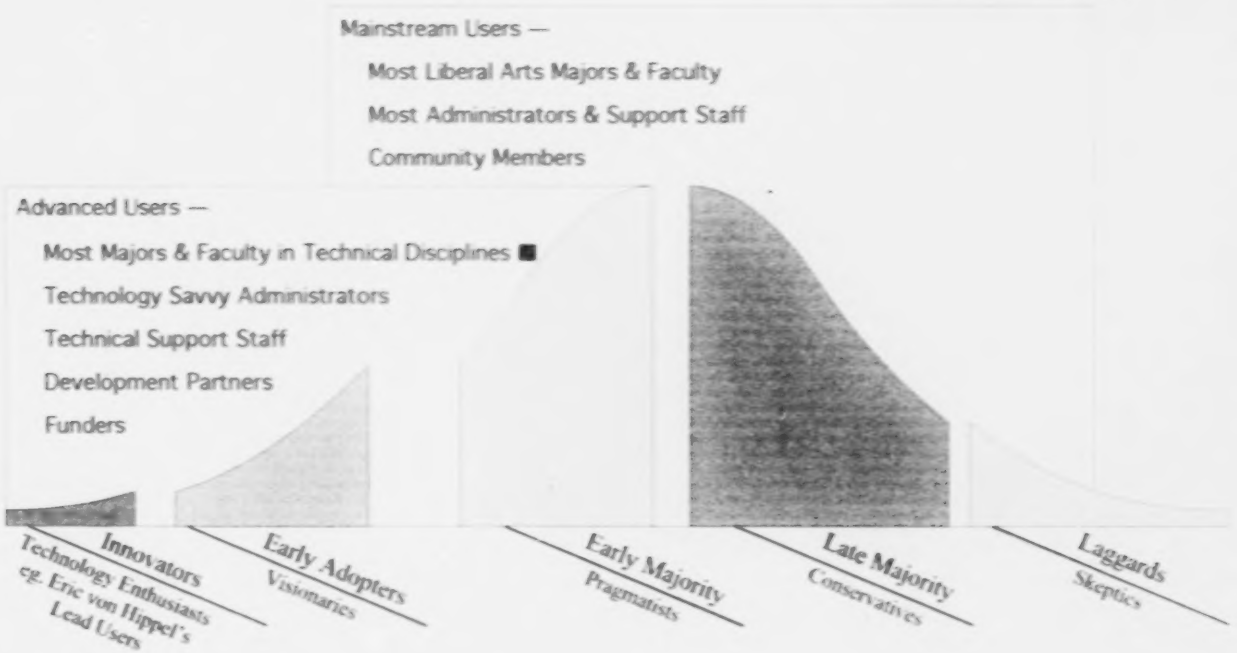
University Technology Adoption Profile ❷

Here we adapt the *Revised* Technology Adoption Lifecycle developed in Geoffrey A. Moore's *Crossing the Chasm* (HarperBusiness, 1991) to profile and loosely cluster ■ technology adoption patterns within the University environment.

Earlier Adopters ◄——————————► **Later Adopters**

Are More Willing to
- accept discontinuous innovation
- fundamentally change work habits
- participate in technology development
- work with unstable products

Would Prefer to
- adopt continuous innovations
- avoid retraining
- leverage existing skills
- use proven products
- receive strong tech support



Core Facilities ❷

Building on the taxonomy above, this chart ■ offers a high level overview of user services that might be offered through The Continuity Project.

	Advanced Users	Mainstream Users
Web-based citation management system	✔	✔
Acquisition, consistent storage, and manipulation of notes, references, & data sets	✔	✔
Modular design permitting upgrades, alternative, & additonal facilities to be added from any source	✔	
Advanced end user software development environment	✔	
Complementary natural language and object-oriented graphic user interfaces	✔	✔
Literate notetaking environment and "scalable content" model for online publication	✔	✔
Intelligent adaptive interface behaviors	✔	✔
Advanced visualization and analysis tools	✔	

■ The labelled boxes reflect a standard distribution of individuals over the subordinate region of the Technology Adoption Lifecycle.

■ This would include most of the Hard Sciences, Mathematics & Computer Science, Quantitative Specialists in the Social Sciences (eg. econometrics), and those working with New Media in the Arts (eg. Computer Graphic Design & Electronic Music).

■ Note that entries are loosely ordered from top to bottom by their likely deployment sequence, although some entries are interdependent. Marks denote those features of primary interest to the indicated reference groups.

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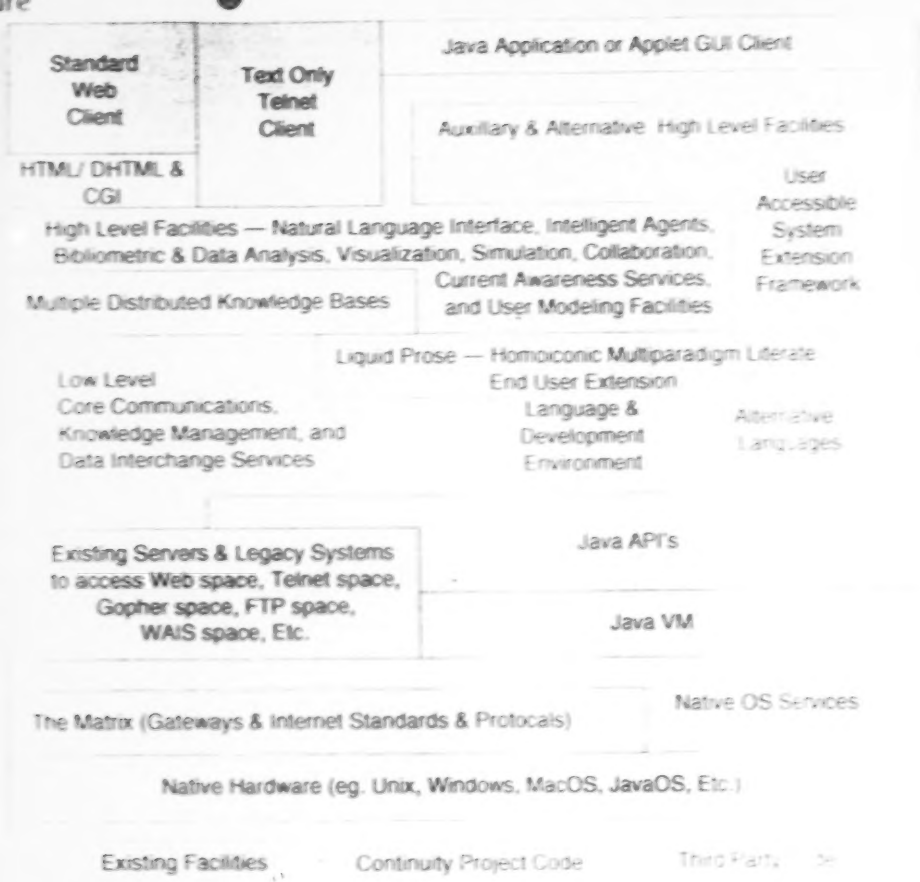
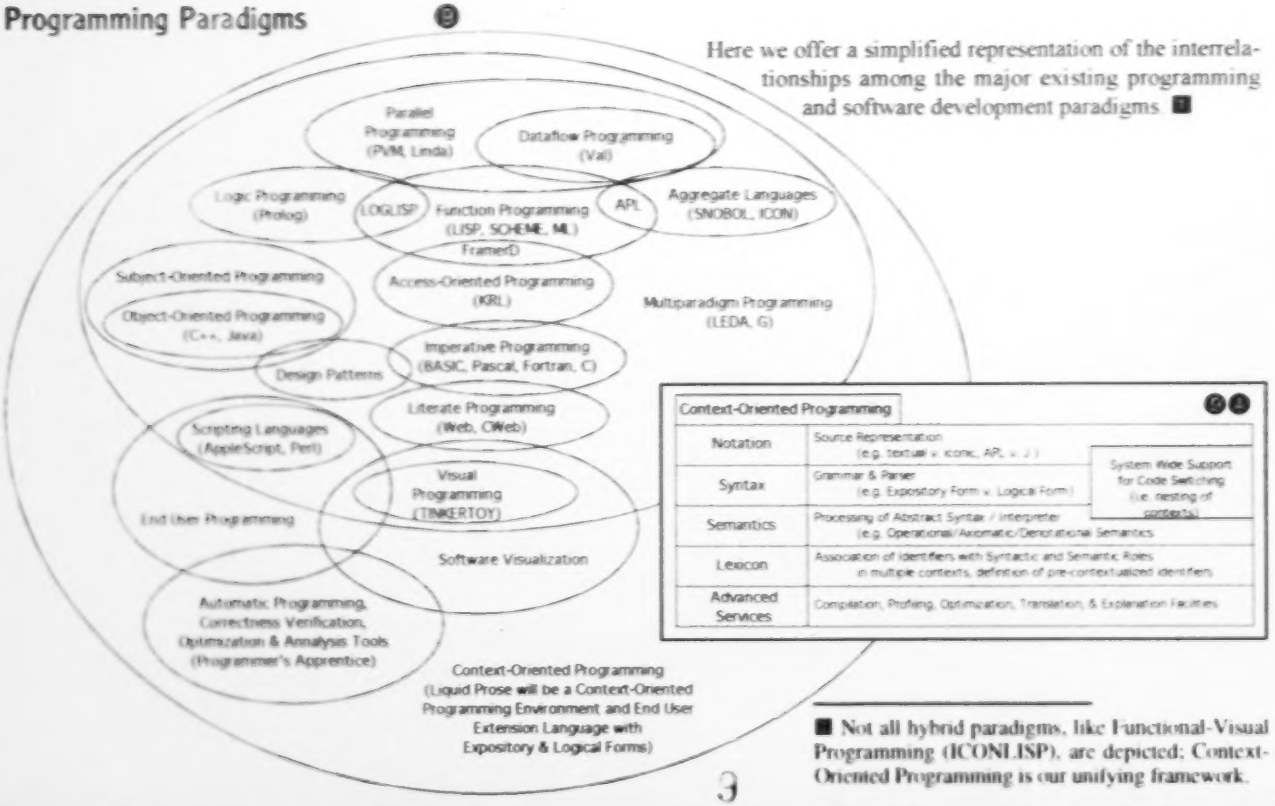
System Architecture


Standard Web Client
Text Only Telnet Client
Java Application or Applet GUI Client
Auxiliary & Alternative High Level Facilities
HTML/ DHTML & CGI
User Accessible System Extension Framework
High Level Facilities — Natural Language Interface, Intelligent Agents, Bibliometric & Data Analysis, Visualization, Simulation, Collaboration, Current Awareness Services, and User Modeling Facilities
Multiple Distributed Knowledge Bases
Liquid Prose — Homoiconic Multiparadigm Literate End User Extension Language & Development Environment
Low Level Core Communications, Knowledge Management, and Data Interchange Services
Alternative Languages
Existing Servers & Legacy Systems to access Web space, Telnet space, Gopher space, FTP space, WAIS space, Etc.
Java API's
Java VM
The Matrix (Gateways & Internet Standards & Protocols)
Native OS Services
Native Hardware (eg. Unix, Windows, MacOS, JavaOS, Etc.)
Existing Facilities
Continuity Project Code
Third Party

Programming Paradigms

Here we offer a simplified representation of the interrelationships among the major existing programming and software development paradigms ■


Parallel Programming (PVM, Linda)
Dataflow Programming (Val)
Logic Programming (Prolog)
LOGLISP
Function Programming (LISP, SCHEME, ML)
FramerD
APL
Aggregate Languages (SNOBOL, ICON)
Subject-Oriented Programming
Object-Oriented Programming (C++, Java)
Access-Oriented Programming (KRL)
Multiparadigm Programming (LEDA, G)
Design Patterns
Imperative Programming (BASIC, Pascal, Fortran, C)
Literate Programming (Web, CWeb)
Scripting Languages (AppleScript, Perl)
Visual Programming (TINKERTOY)
End User Programming
Software Visualization
Automatic Programming, Correctness Verification, Optimization & Annalysis Tools (Programmer's Apprentice)
Context-Oriented Programming (Liquid Prose will be a Context-Oriented Programming Environment and End User Extension Language with Expository & Logical Forms)

Context-Oriented Programming		
Notation	Source Representation (e.g. textual v. iconic, API, v. J.)	System Wide Support for Code Switching (i.e. nesting of contexts)
Syntax	Grammar & Parser (e.g. Expository Form v. Logical Form)	
Semantics	Processing of Abstract Syntax / Interpreter (e.g. Operational/Axiomatic/Denotational Semantics	
Lexicon	Association of Identifiers with Syntactic and Semantic Roles in multiple contexts, definition of pre-contextualized identifiers	
Advanced Services	Compilation, Profiling, Optimization, Translation, & Explanation Facilities	

■ Not all hybrid paradigms, like Functional-Visual Programming (ICONLISP), are depicted; Context-Oriented Programming is our unifying framework.

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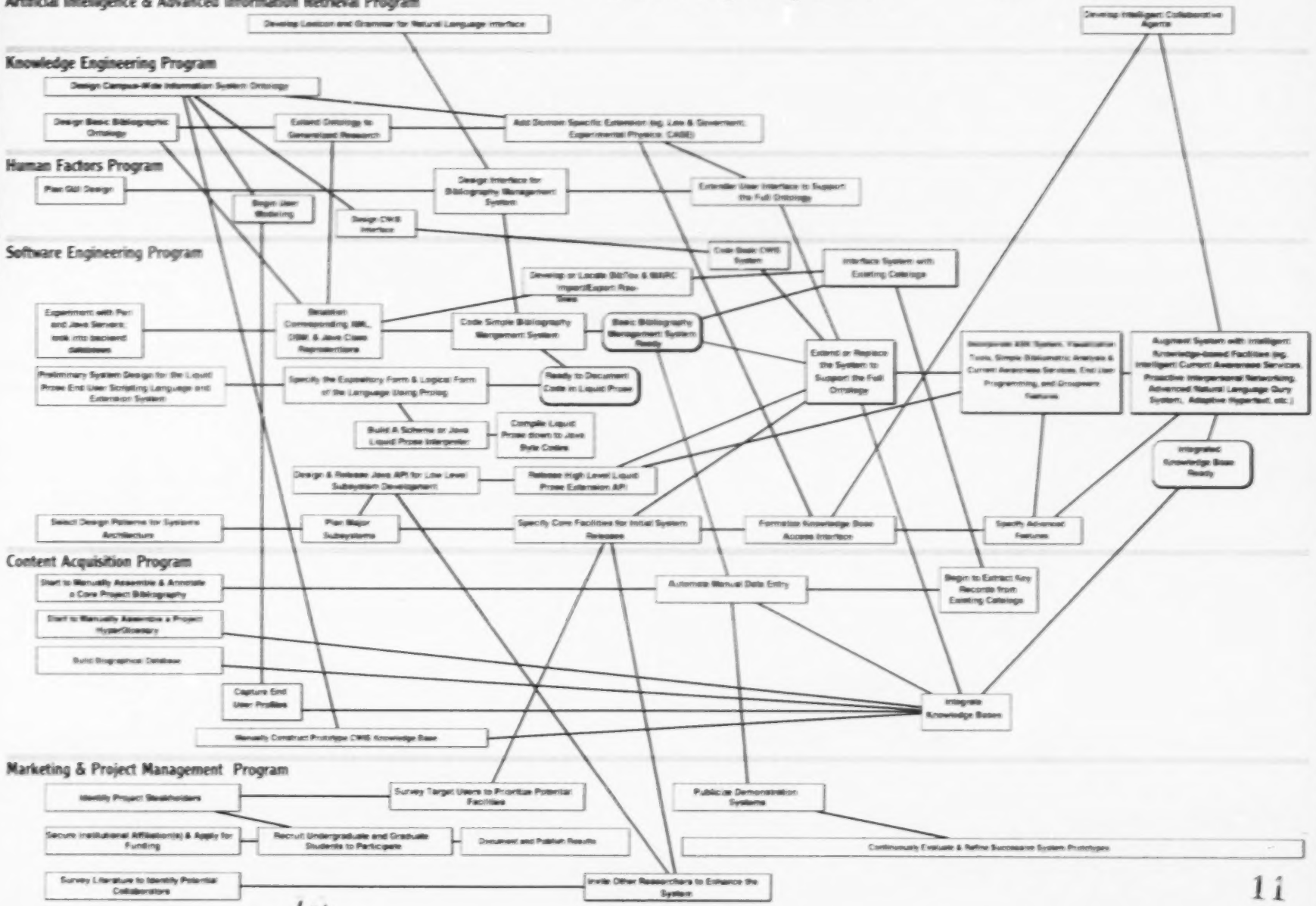
Tentative Project Organization


Artificial Intelligence & Advanced Information Retrieval Program
Develop Lexicon and Grammar for Natural Language Interface
Develop Intelligent Collaborative Agents
Knowledge Engineering Program
Design Campus-Wide Information System Ontology
Design Basic Bibliographic Ontology
Extend Ontology to Generalized Research
Add Domain Specific Extension (eg. Law & Government, Experimental Physics, CAGE)
Human Factors Program
Plan GUI Design
Design Interface for Bibliography Management System
Extender User Interface to Support the Full Ontology
Begin User Modeling
Design CWIS Interface
Software Engineering Program
Code Basic CWIS System
Develop or Locate BibTex & MARC Import/Export Raw-Tools
Interface System with Existing Catalogs
Experiment with Perl and Java Servers; link into backend databases
Establish Corresponding XML, DSM, & Java Class Representations
Code Simple Bibliography Mangement System
Basic Bibliography Management System Ready
Extend or Replace the System to Support the Full Ontology
Incorporate ASK System, Visualization Tools, Simple Bibliometric Analysis & Current Awareness Services, End User Programming, and Groupware Features
Augment System with: Intelligent Knowledge-based Facilities (eg. Intelligent Current Awareness Services, Proactive Intergeneral Networking, Advanced Natural Language Query System, Adaptive Hypertext, etc.)
Integrated Knowledge Base Ready
Preliminary System Design for the Liquid Prose End User Scripting Language and Extension System
Specify the Expository Form & Logical Form of the Language Using Prolog
Ready to Document Code in Liquid Prose
Build A Schema or Java Liquid Prose Interpreter
Compile Liquid Prose down to Java Byte Codes
Design & Release Java API for Low Level Subsystem Development
Release High Level Liquid Prose Extension API
Select Design Patterns for Systems Architecture
Plan Major Subsystems
Specify Core Facilities for Initial System Release
Formalize Knowledge Base Access Interface
Specify Advanced Features
Content Acquisition Program
Start to Manually Assemble & Annotate a Core Project Bibliography
Automate Manual Data Entry
Begin to Extract Key Records from Existing Catalogs
Start to Manually Assemble a Project HyperGlossary
Build Biographical Database
Capture End User Profiles
Integrate Knowledge Bases
Manually Construct Prototype CWIS Knowledge Base
Marketing & Project Management Program
Identify Project Stakeholders
Survey Target Users to Prioritize Potential Facilities
Publicize Demonstration Systems
Secure Institutional Affiliation(s) & Apply for Funding
Recruit Undergraduate and Graduate Students to Participate
Document and Publish Results
Continuously Evaluate & Refine Successive System Prototypes
Survey Literature to Identify Potential Collaborators
Invite Other Researchers to Enhance the System

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Continuity

An Extensible Intelligent Integrated Collaborative Catalog & Distributed Institutional Memory Archive

The Continuity Experience

In these pages you will find an informal treatment of what it would be like to use Continuity in an academic setting.

Since as far back as the 1930's, library and information science researchers have periodically paused to synthesize the work of their predecessors and articulate bold new visions for the future. They suggest new ways to leverage technology and structure our interaction with the written record to offset the natural limitations of our physical and cognitive abilities.

Vannevar Bush's *Reference Selector* and *Memex*, J.C.R. Licklider's *Procog*, Douglas Engelbart's *Augment NLS*, Ted Nelson's *Xanadu*, Daniel Rose's *SCALIR*, and Stuart Sutton's *I*^{E}*X* stand as prime examples of this tradition.

But beyond recapitulating past work and presenting some fixed view of the future, such system archetypes often serve a more functional role in an ongoing design process. Thus *Memex* and *Xanadu* have come to stand for sets of features and design goals that inform commercial and experimental work to this day.

Moreover, in recent years, systems designers have come to realize that it is critical to insuring that the new technology can be smoothly integrated into the social context of its intended use. In response to this need, methodologies like *Participatory Development* (PD), Scandinavian *Cooperative Development* (CD), and more recently *Cooperative Experimental System Development* (CESD) have emerged that rely on scenarios, mock ups, simulations, and prototypes to bring end users into the early stages of the design process. ■ Thus the greatest value of the short vignette lies in its ability to help users and developers form shared mental models and explore the interaction of human factors across the technical dimensions of a system's design space.

It is for these reasons that we ask you to posit a glorious fall day at the start of a not-so-distant semester in which a Continuity system has been deployed on your campus. Putting aside questions of the system's underlying implementation for a time, we ask you to consider how it would effect life on campus. Think about how you would want to interact with the system and your peers, about how it could function as a gateway to knowledge, about how it would effect the economics of information, about what you want the future to look like.

The design and deployment of a complex system like Continuity, and all successful Technology Transfer for that matter, is not a question of passing the ownership of some abstract artifact from its creator to its eventual user. It is in fact, a rhetorical process through which both the technology and the social context of its use are reshaped as all of the participants adapt their mental models and work together creating new knowledge and value. ■

We invite you to become a part of this process and contact the *Director* to share your reactions to these scenarios, so that our work can continue to adapt to better suit your needs.

Gateway to the Campus ①

A visitor arrives at the periphery of the main quadrangle of your campus. He notices a rather dramatic archway that echoes elements of the surrounding architecture while housing a rather large flat panel computer display in one of its sides. The screen reads "Welcome..." in large letters that fade to cycle through several notices, a map, and images of the campus. The stranger draws closer and lingers as an induction coil hidden in the arch detects his presence. After the images cycle, the system toggles from passive to interactive mode and a pleasant voice issues from a hidden speaker notes that, "If you have any questions, or would like directions to, or information about, any people or events on campus, just ask me."

The visitor clears his throat and says, "I am looking for the main library. I have an appointment with Dr. Smith."

The system responds, "Dr. Smith is online now, would you like to talk to him?"

The visitor notices a small camera built into the Kiosk just above its dedication plaque that could be used to make an on campus a video call, but decides to wait and answers, "No."

The system continues, "To get to the Main Library, turn around to face the large brick building..." As the directions are given, the desired route is presented as a 3-D animation in the top half of the screen, at the same time, a correctly oriented photo of each decision point is presented below the animation.

When he finally reaches the library, a differently designed terminal sharing the same interface greets him and helps him find Dr. Smith's office. Later the visitor asks Dr. Smith about the system. He learns that it is called Continuity and combines a campus wide information system and the main library catalog with a number of other "plug-in" features.

Since its introduction, it has become something of a test bed for interdisciplinary projects. For example, the proximity detection features of the Kiosk were developed by graduate

■ See "Toward a Cooperative Experimental System Development Approach" by Kaj Gronbæk, Morten Kyng, and Preben Mogensen in *Computers and Design in Context* edited by Morten Kyng and Lars Mathiassen (The MIT Press, 1997).

■ See *Rhetoric, Innovation, Technology: Case Sidies of Technical Communication in Technology Transfers* by Stephen Doheny-Farina (The MIT Press, 1992).

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students in the Physics Department working with a corporate sponsor who was contracted to manufacture and install similar units that would eventually replace most of the old signage on campus. The rest of the hardware was purchased off the shelf with donations from Alumni who were then invited to work with Communications and Media students to tape short video messages that would be shown to anyone asking the system about them. Most of the software was written by teams of Computer Science students as part of their course work. Art students contributed the on screen graphics and photography while the archway terminals were jointly designed by a local architecture firm and a group of industrial design students. Several of the teams also had participants at other institutions that were collaborating with the Unviersity on The Continuity Project.

"So its not just a card catalog or web site," the visitor concluded, "it is really instrumental to how you combine teaching with research and integrate technology with the humanities."

An Empowering Evolution ②

As lunchtime approaches, two administrators emerge from a meeting elsewhere on campus and shake hands.

"I've got to confess," the older man comments, "I had my doubts about the financials, but the system really worked out. We didn't loose our current hardware investment and the new thin clients have cut our support costs in the clusters."

"I know," agrees his colleague, "I hear that Academic Computing even reinstalled a few ancient ADM's and Volker Craig's in the laundry rooms of the dormitories. Who would have thought that those old text-only terminals could find new life? But the students love them and now that general purpose speech recognition is arriving on our newer high-end systems that same natural language user interface code can serve everyone on campus, even those of us who used to hunt and peck. Now, I still swear by the mouse, and love how I can choose whether the system's Java-based interface looks like Windows or the campus-wide Continuity standard. However, there really are times that it is a lot easier to tell the system what you want than to show it."

The somewhat younger man concurs, "When you combine the mouse with English, the result is a lot more powerful. The amazing thing though, is how smoothly we got here. I mean the whole project sounded a bit wild at first and I figured it would cost us a fortune and we'd never have the talent to pull it off. Instead it seemed to galvanize the campus and all the pieces were already out there. Basing it on Java helped by making it easier for the project team to work with people at other schools and to design the thing so it would be easy to link in existing code. You wouldn't believe how much free code the team members were able to find on the Internet – but I think their attitude is what really made this project work."

He goes on, "From the very beginning they went out of their way to work with everyone on campus, to make it easy for our faculty to get their students involved, and to address our concerns. I mean, when I heard all that talk about system extensibility, I though, 'This is going to be a nightmare to administer. How am I going to handle security and make sure some hacker doesn't bring down the whole house of cards,' the whole thing ran counter to my intuition. But they really had thought it through and arrived at a secure Policy Neutral solution. Now I have some groups doing classified research who maintain very high security and others that are totally open – all within the same environment. It is a lot easier to administer and I think it has reduced some of the tension between my needs and theirs."

Picking up the thread, the older man adds, "You are right about the process being almost transparent. At first they just added those new citation management services over the web and over time they provided more and more, getting more of our students and faculty involved without trying to tell us how we should be using the system. The public relations impact has been a tremendous unexpected boon and as a result we are seeing in-house development that we can really use and that our Alumni and corporate partners are willing to support."

A Tool to Teach With ③

Later in the Main Library, when Dr. Smith checks in with Continuity, he finds a suggestion from the system that certain items cataloged under QA 76.87 and Q335 be placed on reserve because they are being recalled by other patrons at an unusual rate. Donning Java 3-D compliant eye phones and a data glove his office vista is replaced by a color-coded virtual reality representation of the stacks which slowly rotate in front of him highlighting areas of unusual activity. He quickly spots the aforementioned clusters of sources flashing red and calls up a "virtual" menu from which he selects a historical overview. The stacks vanish and are replaced with a compact histogram indicating that about eight titles in the two areas have experienced extreme demand in alternating Spring semesters.

He then asks the system, "Whose students are using that material?" After a short pause, Continuity reveals that his old friend, Professor Bell, is teaching the AI course whose students have been competing for the books. Since she is online in her office, the system offers to open a channel to her and after a short discussion of the reserve situation they find themselves with a few minutes to reflect.

"Thanks for heading off that recall war, Bob."

"No problem, Susan. But we know your students really deserve the credit. They did design the code that filters all of our patron activity for unusual events."

Smiling to herself, Professor Bell observes, "Ah but if you hadn't adopted Continuity, they wouldn't have had programmatic access to actual activity logs, and let's not forget that a lot of the code was already available through the source repository you helped the Continuity team to develop. Also the actual evaluation function itself is written in an APL derivative based

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on Psi Calculus that can automatically configure the computations for efficient execution on our multiprocessors or distribute them across a processor pool."

Dr. Smith interrupts, "Whoa, you are starting to loose me."

"Its really pretty simple. In a nutshell, Continuity lets us mix and match different programming languages and makes it easier for different groups of programmers — the Rhetoric people would call them Discourse Communities — to exchange and document code. In some cases it can translate the code between computer languages, explain it to a non-programmer in English, or make it run faster by changing how it behaves to make the best use of the computers we have available to run it on," the Professor explains.

"You know, Susan, I am not nearly as excited about mixing programming languages as I am about how the underlying system makes it possible to for us to mix and customize automation solutions here in the library. Before Continuity, we had to pick one commercial package every five years or so. Now the newer ones may have been modular, but the same vendor would still control all of our options. We could never mix and match system components developed by your students with the best tools from several companies. We are seeing more competition now, lower prices, and better facilities. Moreover, we can even maintain alternate implementations of the same facilities since the underlying data models remain constant."

Professor Bell eagerly agrees, "Yes, and my students can work with your staff and pick simulations of the system apart as they learn without compromising any data or security. In fact we are seeing a lot less 'hacking' now that we have so many new 'legitimate' outlets for students to make lasting contributions and to work with commercial developers while enhancing their portfolios."

"Moreover, instead of starting from scratch on each assignment they can call up work from past semesters and refine it. Our emphasis has shifted from writing 'toy programs' to enhancing a large evolving system with less experienced coders working on the routine features. They don't work in a vacuum either, they start with Continuity's literature pointers and network more with their peers."

"Then once they've proven their competence writing well thought out understandable code, they are encouraged to take on bigger projects, seek advice from local experts, and enlist more junior students to help them with some of the implementation details. It used to be that you'd only see that kind of bootstrapping at places like the MIT Media Lab. Now we do it here too, and students are learning more than ever! As a result, the distinctions between the way undergraduates and graduates pursue their studies aren't quite so stark as they used to be, and I'd say Comp. Sci. is no exception in this regard."

Dr. Smith grins and confesses, "You know, some of us were a bit concerned at first that all this new technology might somehow diminish our role as Librarians. On the one hand we had your AI grads wanting to graft agent technology into the catalog so it could start taking semi-autonomous actions — and none of us knew how that would play out. Then on the other hand the Continuity people also wanted to build user profiles and collect user generated metadata to supplement our controlled vocabularies and cataloging decisions. At first we didn't know what to make of it. Some of us wanted to do our own development, others wanted the stability of commercial products that seemed to keep falling just short of what we really wanted."

"Then we met the team and they explained the micro-preference system they were designing to help us evaluate sources. They even outlined ingenious social control heuristics to encourage end user cooperation and comprehensive security mechanisms to keep any malicious users at bay."

"I suppose privacy was your biggest concern," Professor Bell interjects.

"Well, it was a first," Dr. Smith replies, "But the team had that covered too. Part of the solution was technical, making sure that the system knowledge base was secure from statistical attacks and the like. They provided very fine grained access control and even gave patrons the option of storing their extended profiles on their own PC's. But with the exception of research in personal health issues, and a handful of otherwise sensitive topics that we screen from individual profiling by default, most of our patrons don't mind sharing their research activities. They don't even mind if the system interrupts them with a question from one of their colleagues, since this is one of the ways that Continuity learns."

Professor Bell sums up the thought noting that, "Continuity has a cybernetic quality. You see, Bob, there really is an implicit social contract at work here that is reinforced by the system's long term behavior."

"You may have a point," Dr. Smith counters, "but you know what? I'm too busy to worry about how the system works. I can't remember a time when the Library has worked so closely with the academic departments, instead of being marginalized by the arrival of this technology, we have broadened our support base on campus. For the first time we are starting to be thought of as something of an academic unit in our own right. Continuity has freed up a lot of time for us to concentrate on teaching our patrons how to evaluate and work with the resources at our disposal. Continuity's ontologies and visualization tools are making our classification systems and thesauri accessible to the average reader. We get to play a bigger role at academic conferences and to help you and your students implement and evaluate new ideas."

As the sun sets on the campus, Professor Bell enthusiastically concludes, "Now that Continuity is in place, we are doing a better of job teaching, attracting world-class talent and funding to our campus, and also, we are having a lot more fun around here!"

Continuity *An Extensible Intelligent Integrated Collaborative Catalog & Distributed Institutional Memory Archive*

Project Participants

Peter J. Wasilko, Esq.
J.D., LL.M.

Our Project Director & Principal Investigator

My academic pursuits have long been characterized by a high level of interdisciplinary work in which I've found our current library catalogs woefully inadequate while paradoxically using them to discover just how much progress was being made in the state-of-the-art research systems to which they bore so little resemblance. I think this observation was the core motivation that led me to concentrate in *Law, Technology, and Management* at *Syracuse University's College of Law* and to take credits in *The School of Management's Innovation Management Program*. Later, while researching potential applications of a ground breaking inference engine for *Syracuse University's Technology Transfer Research Center*, I seized the opportunity to work with Professor Stuart Allen Sutton of the *School of Information Studies*. His Ph.D. dissertation on *Managing Legal Information: A Model of Institutional Memory Based on User Cognitive Maps* opened up a whole new body of literature to me at about the same time that I was experimenting with an early beta release of *Eastgate System's Storyspace* that the University was testing in one of its labs. These experiences in synthesizing patterns of thought and research drawn from the domains of law and management with Information Science and Hypertext technologies formed the seeds of Continuity.

After graduating with my J.D. and LL.M., I was finally free to focus more intensely on integrating the assorted strands of research that I had been so carefully cultivating. Soon, I started looking more at semistructured hypertext systems and drew insights from some of the developers of *NoteCards* at AAAI '93 & IAAI '93 in Washington, D.C.

By that point I had found that the earlier works of a field often provided a better entry point to the literature of a discipline than more current ones, with Ashby's *Introduction to Cybernetics*, Nicholas Negroponte's *Architecture Machine* series, Marvin Minsky's survey of *Semantic Information Processing*, and of course J.C.R. Licklider's seminal *Libraries of the Future* serving to best illustrate this heuristic!

Of course, one also must look to current efforts. Through the Web and the Literature, I've come to observe that most digital library-related projects, tend to cluster around either the development of specific advanced facilities (e.g. self-organizing concept maps) or the construction of generic digitization & multimedia delivery systems. Projects in the former class excel at providing context while those in the later class excel at providing content. Content delivery research promises a day on which every page in the world will be imaged and accessible on our desktops, but it will likely fall short in helping us to manage such bounty. Context navigation research holds out our best hope to avoid a major cataloging crisis if we can integrate it into our systems. To do, so we may have to revisit decisions about who should catalog, what should be included in our catalogs, and how our libraries can help their patrons cope with the explosion of unrefereed sources in the age of the World Wide Web.

And yet, as I have delved ever deeper into the record [1], I have found an untraveled fork in the road, a path not taken dating back to Vannevar Bush's unpublished speculation on *A Reference Selector* in 1937 [2]. That most remarkable exposition embodies the earliest seeds of the solutions presented herein. Had Bush remained active and pressed forward with this vision, perhaps as an active participant in *Project Intrex* with J.C.R. Licklider, we might live in a very different world today [3]. And yet "after the war years rather completely knocked [him] out of all things [he] had been trying to do, [he] never did go back into [library research]." [4]

But when Bush and Licklider were at the height of their powers, the technology to create the systems they envisioned was still in its infancy. Today we can refine that vision and finally make it a reality. To my mind, we need an ***Extensible Intelligent Integrated Collaborative Catalog & Distributed Institutional Memory Archive***. We have the technology and the talent. The costs for such an initiative would be negligible compared to the "brick and mortar" capital projects we commonly work to advance; and the potential returns from such an investment in the ***human capital*** to create an ***information infrastructure for the future*** would be tremendous.

Now is the time to forge the future!

— Peter J. Wasilko, Esq.

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[1] Paul Kahn and James M. Nyce, "A Machine for the Mind: Vannevar Bush's Memex" in *From Memex to Hypertext: Vannevar Bush and the Mind's Machine* edited by James M. Nyce and Paul Kahn (Academic Press, 1991)

[2] Vannevar Bush, *A Reference Selector: Description of a Possible Method for Facilitating the Preperation and Use of Evaluated Bibliographies*, (1937) Item RG 1.1 224D 2 23, provided by The Rockefeller Archives.

[3] *A letter from J. C. R. Licklider to Vannevar Bush dated July 22, 1965* filed with materials on *Project Intrex* in The Vannevar Bush Papers MC78, Box 20 provided courtesy of The MIT Archives.

[4] Id. Vannevar Bush, *Draft of Talk for Woods Hole Conference*, 2 August 1965.

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Our Project Advisory Board

In order to ensure that Continuity embodies the best practices and has the depth and breadth to serve as an open ended platform ready to receive tomorrow's discoveries, we have established a ***Project Advisory Board*** of leading outside experts with backgrounds in the core technologies we are hoping to integrate into the project. They have volunteered to review our progress and offer pointers to resources, literature, options, and contacts, which might otherwise elude us.

Our Current Board Members (in order of appointment) are:

• **Gerry McKiernan**, M.S. in Library Science, *University of Illinois at Urbana-Champaign* — Curator of the *CyberStacks(sm)* at *Iowa State University*.

Gerry is a key player in the establishment of clearinghouses to facilitate the development of new millennium library catalog systems.

• **Mark Bernstein** Ph.D., *Harvard University* — Chief Scientist at *Eastgate Systems, Inc.*

Mark is enjoying a remarkable career developing serious Hypertext software while playing an active role in many scholarly conferences.

• **Susan Thomas**, Ph.D. — *Syracuse University's Maxwell School of Citizenship and Public Affairs*.

Susan has taught in *The Innovation Management Program at Syracuse University's School of Management*. Her research centers on Innovation Management, The Global Economy, and Creation Setting.

• **Steven J. McCaffrey**, B.S. — Computer Science and Applied Mathematics, *University at Albany*.

Steve is an independent scholar, programmer, and technology accessibility advocate for the disabled.

• **Ron Kalinoski,** M.S., *The University of New Mexico* — Coordinator of the Distributed Staff Program, Software Assets Manager, & Listserv Manager, *Syracuse University Computing and Media Services*.

With his 17 years at *Syracuse University*, in such positions as Associate Director of Research Computing and Director of Faculty Computing, Ron offers a unique perspective on technology adoption, usage, and end user support.

Please note that in recognition of the many competing demands on the time of our board members, we take every measure to ensure that they remain in control of their level of participation and can enjoy a rewarding relationship with the project without investing major blocks of their precious time.

If you might be interested in joining the Advisory Board, do feel free to contact our *Project Director*, ***Peter J. Wasilko, Esq.*** to discuss how we might arrive at a mutually benefitial arrangement.

Our Colleagues

We are always looking for new opportunities to collaborate with our peers and would therefore welcome any research pointers, leads to possible host sites and project sponsors, or opportunities to help you integrate your own research into the project's framework so we might better leverage our resources.

We would particularly like to thank our many colleagues in the libraries, research centers, administration, and faculty of ***The State University of New York at Albany*** and of ***Syracuse University***, who have made time in their busy schedules to meet with the Director and offer their feedback and sage advice on advancing the project. We look forward to this continued dialog and hope to work more closely with them in the future.

As our implementation drive starts to get underway in the months ahead, we will continue our search for the *right site* to physically host the project's core researchers. But rest assured that our work and culture are highly ammenable to a multi-site approach. So if you have a program or research that complements our efforts, there is a good chance we can find a way for you to participate!

Our Research Associates

Of course the deepest goal of The Continuity Project is to create a framework in which diverse technologies and academic disciplines can be brought together to support and to more closely integrate research & teaching in the University.

Thus we especially welcome inquiries from graduates and advanced undergraduates who might like to volunteer to participate in the implementation of various Continuity subsystems either as part of their academic programs or as an extracurricular activity to enhance their résumés.

During the Spring Semester of 1998, we took our first steps in this direction by beginning to work with ***The Soling Program*** — *The Problem Solving Program of the College of Arts and Sciences at Syracuse University*. Through this innovative practicum, undergraduates from a variety of disciplines are afforded the opportunity to work together solving real world problems.

Our first team of ***Soling Research Associates*** consisted of four *Illustration* and *Communication Design Majors*, ***Jason Kramer***, ***Miranda Dove***, ***Jen Manell***, and ***Jesslyn Wicklund*** — all of whom offered us invaluable perspective as potential end users of Continuity while helping us refine our graphic identity. It also gives us great pleasure to report that of the group, ***Jen Manell*** has volunteered to continue working with us over the next few months as our ***Summer Research Associate***.

Thus we would like to thank all of our students and offer the highest praise to ***Professor Frederick W. Phelps***, *Director of The Soling Pgoram* and ***Donna G. Thomas***, the program's *Academic Advisor* for their support and assistance.

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Sources of Inspiration

The epigraphs on these pages reflect the rich body of literatature from which The Continuity Project has drawn its inspiration.

Captured herein are some of the highlights of the last half-century of thought on the future of the library and the role of information systems in our pursuit and organization of knowledge.

Over this period we have achieved unimagined technological achievements that have brought us back full circle – armed with the ability to finally realize the visions of our greatest pioneers.

Yet even the expert today has often to ignore past work in his field because of the labor of getting at it; because of the inescapable preliminary drudgery he may be deterred from tackling even a problem which he is especially qualified to attack, thinking it better to put his skills on other tasks. ...

The pressing of a button should place immediately on the desk not merely one book or one article, but every appropriate item which the individual has collected, every thought or theory which he had formed or recorded, plus all those data which cooperative judgment had shown to be useful in attacking the problem under consideration. ...

... the device will implement cooperation and aid in giving to the "fellowship of learning" the instrumentality which is implied in that term.

Professor Jones is a spectroscopist... He has an article in the Physical Review before him and, not once but several times in the course of this article, he writes mysterious words in the margin. ... In the course of an evening he makes 30 or 40 such entries. ... He tosses the journals he has reviewed into a basket marked "library", and forgets them. After a day or two the journals appear back on his desk stamped "entered".

... Six months later he meets a student named Smith in the corridor. Smith has got to the point in his research where he wishes to examine the spectrum of doubly ionized lithium, so he asks the professor what is the best method of obtaining it. "Read the literature on the subject for the last year, and we will then discuss it," says Jones and goes his way.

Smith, in the library, consults a code book and writes his initial on a slip, together with the ['code word' for the topic] and "recents," and passes it in at the desk. The attendant [keys it in and returns with] a strip of photographic paper. On it appear a dozen items. One of these reads: "217,384, Phys. Rev. Oct. '36, P. 483, Osborne, U. M. 3846, Precise Examination of a Series of stripped Atoms, methods of exciting double ionized lithium, Electrodeless discharge. should be checked and, if found operative, will supersede prior methods. KSJ."

Much of this is self-explanatory. The first number is the serial number of the item, so that it can be readily found if Professor Jones should later order it amplified or cancelled. The U. M. gives the location where the author, Osborne, performed the experiment. The 3846 is the shelf number in the library where the Journal is to be found. Then follows the title of the article, and finally Jones' comments of six months before and his initials. Here are placed before Smith all the pertinent references within articles, on the specific matter of inquiry, with critical comments by experts in the field. Smith has saved a week's hunt, and he has all there is to be had.

The multiple intelligence of the reviewers whose judgments are stored for the use of others is the king-pin of the machine. To the individual reviewer, then, the machine will offer a new opportunity for usefulness, a consequent new dignity. More immediately, what will it mean to him? Many things, of which these so soon can be clearly foreseen: The peace of mind which comes of being able to have a judgment on the literature of his subject recorded quickly and accurately, stored safely, recalled instantly; the accession of energy for other things which comes of this freedom; the sharpening of thinking which comes of the corroboration of his judgment, or the criticism of it, by fellow reviewers in his field; the increase of effectiveness and efficiency which comes of the foregoing values; the widening of his range of thinking and acting which comes, to the reviewer as well as to the student, through familiarity with and use of the service offered by the device. If he is a teacher, he will be able to transmit to students his thoughts in specific, not general terms. If he is a researcher, he will be able to communicate to his colleagues his judgment by direct, not slow and unwieldy means. The machine will thus, whatever his main activity, implement him to perform his work more readily and more fully, and so will help him in transcending the limits which his physical self places upon his intellectual effectiveness.

– A Reference Selector

Vannevar Bush, 1937

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It consists of a desk, and while it can presumably be operated from a distance, it is primarily the piece of furniture at which he works. On the top are slanting translucent screens, on which material can be projected for convenient reading. There is a keyboard, and sets of buttons and levers. Otherwise it looks like an ordinary desk.

...Thus he goes building a trail of many items. Occasionally he inserts a comment of his own...

And his trails do not fade.

– As We May Think, 1945

Question: Has any digital-computer system responded to questions phrased in ordinary English, or other natural language, by giving correct answers in natural language?

Requested bibliographies will be available at about 18:00. Do you want them delivered, or will you call, or will you request typeout?

Unfortunately, my office is not located near a pneumatic tube station.

Refer to bibliographies I requested last Friday.

Do cited or related references contain explicit definitions of "syntax", "syntactics", or "semantic"?

– Libraries of the Future, 1965

In essence, this new model is based on the social construction of knowledge...

... focus is now upon computer support for the conversation of knowledgeable peers—the social content of the interface is predominant...

– The Society of Text, 1989

I am in cyberspace. I once again resort to a freer writing, a writing more fluid and random....

Every paragraph an idea, every idea an image, every image an index, indices strung together along dimensions of my choosing, and I travel through them, sometimes with them, sometimes across them....

...Like a bird of prey my acuity allows me to glide high above the plains of information, seeking jewels among the grains, seeking knowledge.

I sense the presence of others. I see the traces of passage, the flares of trajectories of other searches. Those who share my interests visit the spaces around me often... I open channels and request communication. They blossom into identities that flow in liquid metamorphosis.

– Cyberspace: First Steps, 1991

...when we design computer media we are hardwiring a mechanism for the social construction of knowledge.

...Ten years from now our old card catalog may well have metamorphosed into a "virtual library" of its own. It should be possible to "browse" the stacks without leaving the terminal; to "open" a book and view its table of contents; perhaps even, to flip through the pages of two books, physically located on different levels of the stacks and compare them.

– Sociomedia, 1992

The computer textualizes everything: it is our writing of the world as we know it, a map of illiteracy. It must always contain a black space, a margin in which to write...

... empowerment may be just as important a goal as simplicity for many users.

– Contextual Media, 1995

The gateway is a metaphor for access to knowledge and evokes the image of crossing a threshold and entering a dramatically expanding world of information and learning. The library, as gateway, is the means by which students and faculty will locate and use this information. ... the gateway we envision is the constellation of services, the organization required for providing these services, and the spaces dedicated to student learning. ...

Planning for the gateway library must begin with a rethinking of what libraries can accomplish and what librarians ought to do. Because fewer distinctions can be drawn today between information and the tools for managing it or between libraries and campus information infrastructures, assumptions based on past levels of computing and network performance, on the persistence of user-hostile software, and on excessive labor and hardware costs will be invalid and dangerous guides for the librarians who are charged with designing the future. ...

I define the gateway library as an integrated and organized means of electronic access to dispersed resources. The gateway library is therefore a process that delivers services to the user. ...

Two terms — *digital library* and *gateway library* — contend today for the status of high jargon in the library community. ... However, digitization itself provides no service to those seeking information: the digital library is only a collection in another form. Until the data in the digital library are organized into information, we will have what we now see often on the Internet: an unedited, unevaluated, unusable mélange of documents.

We require something more than a collection. ...

– Gateways to Knowledge, 1997

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